Report Documentation Page

Form Approved
OMB No. 0704-0188

Public reporting burden for the collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington VA 22202-4302. Respondents should be aware that notwithstanding any other provision of law, no person shall be subject to a penalty for failing to comply with a collection of information if it does not display a currently valid OMB control number.

1. REPORT DATE	2. REPORT TYPE	3. DATES COVERED
AUG 2011	**N/A**	**-**

4. TITLE AND SUBTITLE	
A Paradigm Shift: Composite/Smart Systems Innovation through Nanoscience, Life Sciences and IT Technologies	5a. CONTRACT NUMBER
	5b. GRANT NUMBER
	5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)	5d. PROJECT NUMBER
	5e. TASK NUMBER
	5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **US Army Research Laboratory Washington, DC**	8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)	10. SPONSOR/MONITOR’S ACRONYM(S)
	11. SPONSOR/MONITOR’S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT

Approved for public release, distribution unlimited

13. SUPPLEMENTARY NOTES

See also ADA555447. International Conference on Composite Materials (18th) (ICCM-18) Held in Seoul, Korea on August 22-26, 2011. U.S. Government or Federal Purpose Rights License

14. ABSTRACT

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT	b. ABSTRACT	c. THIS PAGE			
unclassified	**unclassified**	**unclassified**	**SAR**	**2**	

A Paradigm Shift:
Composite/Smart Systems Innovation through Nanoscience, Life Sciences and IT Technologies

By
Jim Chang, Chief Scientist
US Army Research Laboratory
Washington, DC

The smart structures and smart systems have been one of the major contributions from the composite materials and structures community. With the advancement of the sensor and actuator technologies and control theory, the smart systems/structures have been developed and built "parasitically". Specifically, based on the control theory, sensors and actuators are placed at the strategic locations to manipulate the sub-elements in a system/structure for achieving more desirable, controllable and efficient system/structure, and oftentimes to arrive at structural health monitoring and self-healing capability. The success of this approach has been enormous and the applications are ranged from civil infrastructures to automobile and to aerospace systems.

However, the nature's smartness is not achieved "parasitically" but built-in "organically". For example, the bees and birds are substantially more agile, more efficient, more robust and more energy efficient than any their man-made counterpart. Therefore, the ultimate goal is to learn from the nature and build man-made systems where the smartness is "organically built-in". To achieve this vision, the smartness must be derived from the neurological-like sub-systems which are small, distributed, agile and responsive. The advancement in nanotechnology, information technology and life sciences has opened the doors for us to realize this vision.

Nanotechnology gives the capability for producing small and reliable sub-systems that can be integrated into a system/structure to achieve smartness. The advancement in nanotechnology processing has demonstrated that one can design and fabricate "built-in" functionalities (mechanical, thermal, electrical, magnetically and optical) by introducing nanoparticles or nanoelements into nanofibers the fundamental building blocks of a composite material/structure. With these functionalized nanofibers, distributed smart network can then be constructed and integrated into the systems of interest having sensing and actuation capability from mechanical, thermal, electrical, magnetic or optical stimulation and to arrive at the desired smartness. The knowledge from learning-from-natural will point-the-way to the material smartness development and to facilitate smart network development and design. The advancement in information technology will not only enable one to design smart network but also provide theoretical basis for systems control for their robustness and efficient operation. Since the organic "built-in" smart systems/structures are made of neuro-like networks, there are small, light weight, distributed, multifunctional and with extreme high efficiency in performance and in energy utilization. Additionally, because the smartness is not from the parasitic add-ons but from with-in organically integrated systems/structures, they are much more durable and long lasting.

The conventional composite materials are an integration of different material phases. Traditionally, these phases are being dealt with at marco-scale level and primarily for their mechanical performance with success. However, for the smart systems/structures discussed,

both nano-to-macroscale scale and other functionalities (mechanical, electrical, magnetic, thermal and optical) are major ingredients for designing sensing and actuation capabilities into the systems/structures. Therefore, conventional composite materials tools are inadequate and much advanced research is needed. For example, a multiscale (theory, analysis and experiment) theory coupled with experiment and simulation codes is essential to adequately address the integration issue resulting from the nano-to-micro systems/structures with mechanical, thermal, electrical, magnetic and optical functionalities.